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1985 FISHERIES HABITAT AND AQUATIC ENVIRONMENT MONITORING REPORT-ROCK CREEK  
DRAINAGE OF THE DEERLODGE NATIONAL FOREST

JUN 10 1999

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DEERLODGE NATIONAL FOREST

In cooperation with

MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

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1985 FISHERIES HABITAT MONITORING REPORT- DEERLODGE NATIONAL FOREST

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## INTRODUCTION

Accelerated rates of surface erosion and mass wasting resulting from logging or roading have the potential to increase levels of sediment delivery to forest streams beyond "natural" or background levels. Streams vary in their abilities to transport increased sediment loads, depending on factors such as channel gradient, discharge, bed roughness, and sinuosity. These factors influence how much sediment delivered to a stream may be transported out of the system during high-flow periods when the additional energy necessary to carry that load is available. As peak flows recede, this energy becomes decreasingly available, and deposition of the suspended or bedload sediment load occurs. Once deposited, sediment remains as part of the substrate until sufficient stream energy develops to dislodge the sediment and transport it downstream. Sediment is a naturally occurring material in stream systems. If supply of sediment to the stream exceeds the stream's ability to transport sediment from the system, the existing equilibrium is changed and the result is additional storage of sediment within the stream substrate.

Adverse effects of sediment on biological communities has been well documented. Public concerns about the effects of accelerated levels of Forest originated sediment has raised the priority for gathering additional data on sediment and its effects on biological communities. Substrate sediment measurements, and the response by both the invertebrate community and the fish population are the focus of this monitoring effort.

One method of evaluating and rating the degree of substrate sediment deposition within a stream reach is by measuring the relative "embeddedness" of that substrate. Embeddedness is defined as: The degree that larger streambed particles are surrounded or covered by fine sediment.

Embeddedness levels are often used as indices in evaluating a channel substrate's suitability for biotic productivity, because embeddedness has been demonstrated to be a key characteristic in describing fish habitat suitability. As the amount of deposited sediment (embeddedness) increases, the quality of instream cover provided by the channel substrate decreases. In addition, embeddedness levels have been used to evaluate the substrate's suitability for spawning, egg incubation, and macroinvertebrate habitat.

Embeddedness is also used to translate the amount of sediment delivered to a stream to fish consequences as displayed in the Forest Service R1/R4 Sediment Fish Response Model used to demonstrate that the preferred alternative of the Deerlodge National Forest is not expected to result in an adverse effect on fish in the Rock Creek drainage.

## OBJECTIVES

Sampling of embeddedness levels, macroinvertebrate communities, and fish populations were initiated during the summer of 1985 with the goal of providing data on the following subject areas over the next several years:

- 1) Gather baseline embeddedness data for future comparisons of embeddedness trends over time in drainages impacted in the past or in drainages with development proposed in the future.
- 2) Compare embeddedness levels by morphological position (i.e. riffles, runs, pool tailouts).
- 3) Compare fish population response to changing levels of embeddedness on study streams. The Montana Department of Fish, Wildlife, and Parks has the primary for the collection and summarization of population data

Evaluate other habitat components (i.e. pool quantity, cover) that may compensate for sediment increases as indicated by fish populations.

- 4) Compare macroinvertebrate community composition and biomass in riffles as embeddedness levels change.

This project will be supported by hydrologic and sediment transport data gathered by Forest hydrologists.

Null hypotheses to be tested include:

Ho1 There is no change in stream embeddedness levels in monitored streams as drainages are developed.

Ho2 There is no change in invertebrate community species abundance in monitored streams as the drainages are developed.

Ho3 There is no change in the fish populations of monitored streams as the drainages are developed.

Ho4 There are no differences in embeddedness found in the different riffles of the same stream reach; i.e. that any riffle is the same as another in the same stream reach.

Ho5 There are no differences between percentage embeddedness expressed by the extraction/individual particle measurement technique and the surface ocular measurement techniques

#### SAMPLE DESIGN

The primary focus of the project is to establish long-term monitoring stations on a number of streams draining watersheds of different geologic origin. Many of these streams have proposed land management activities scheduled in the next decade. Other streams may be used as controls. Most of the objectives listed above will be met and hypotheses will be tested with this portion of the monitoring effort.

The streams selected for monitoring stations were chosen for a number of reasons, including (1) the drainage represented a previously undeveloped drainage of a relatively pure geologic type; (2) a land management project of

potential biological or political significance was proposed; and (3) previous long-term hydrologic stations had been established with corresponding sediment delivery and streamflow data available.

Streams on the adjacent Bitterroot and Lolo National Forests have also been selected for monitoring using the same parameters so that the data base related to stream sedimentation and its effects on biological communities may be larger than possible for a single Forest to provide. Extrapolation between streams of similar geologic origin, size and gradient may be possible as the data base is developed, and the increased sample size provides greater reliability of relationships than one Forest alone may be able to provide.

Streams Selected for Embeddedness,  
Invertebrate, and Fish Population Evaluations

<u>Stream</u>	<u>Significance</u>
Middle Fork Rock Creek	Belt series geology
West Fork Rock Creek	Idaho batholith granitics; development proposed
Main Rock Creek	Measure effect of cumulative management activities on main stem
Ross Fork Rock Creek	Dominantly granitics
Sand Basin Creek	Small granitic watershed. Development proposed.
Bowles Creek	

EMBEDDEDNESS PROCEDURES, ANALYSIS, AND DOCUMENTATION METHODS

Methods for sampling embeddedness were adapted from Burns (1984).

Sampling was conducted at each location by randomly throwing a 60 centimeter diameter steel hoop into an area of the stream predetermined and boundary delineated as representing one of the three morphological positions (riffle, run, or pool tailout). Samples were only taken if the area within the hoop met the following criteria:

- 1) Hoop must fall in the center one-third of the active channel or where bank deposition is not obvious
- 2) The hoop or part of the hoop is not in an eddy caused by either a pool or large boulder.

In sites meeting the above criteria, a 30-centimeter transparent ruler affixed to a plexiglas frame was used to measure each free matrix particle (non-embedded) and embedded matrix particle between 4.5 and 30.0 centimeters in diameter within the area of the hoop. Starting at one side of the hoop, all free matrix particles were systematically removed and measured for the greatest

diameter, perpendicular to the plane of embeddedness (d1). Next, all embedded matrix particles were removed and measured for both (d1) and (d2), the distance along (d1) which is covered by fine sediment ( $< 6.3$  mm diameter) or "embedded" in the stream bottom (Figure 1).

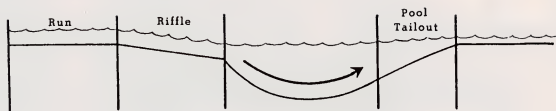


Figure 1. Hypothetical stream profile indicating morphological positions sampled for embeddedness.

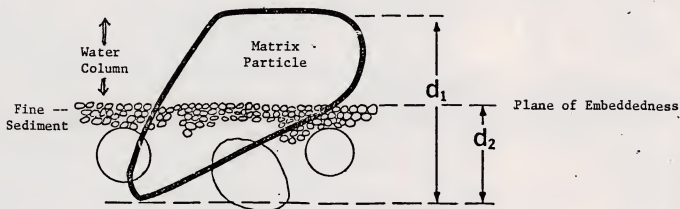


Figure 2. Diagram indicating the embeddedness measurements of an individual substrate rock (from Burns, 1984).

Each matrix particle to be measured was removed by grasping it with the tips of the thumb and fingers at the plane of embeddedness. This hand position, which marks the plane of embeddedness, was maintained while transferring the particle to the plexiglas measuring device. Occasionally, changes in hand position were required to remove large particles. In such cases, other indicators (i.e. algal stains) or methods of marking the plane of embeddedness were used.

Measurements of ( $d_1$ ) and ( $d_2$ ) were taken by placing the particle against the plexiglas plate holding the transparent ruler, while insuring the end of the

particle was firmly placed up against the adjacent (at right angle to) plexiglas plate. From this alignment, using the maintained finger position described above, the measurements (d1) and (d2) were read (Figure 2).

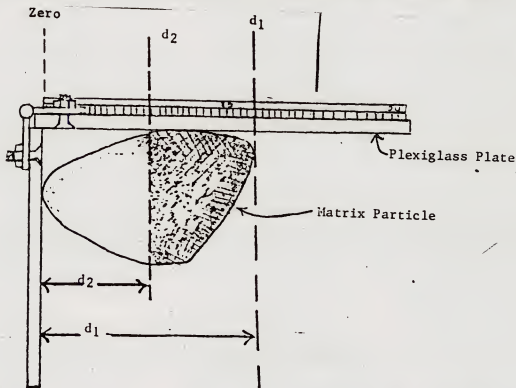


Figure 3. Diagram of substrate rock placed on embeddedness measurement instrument (from Burns, 1984).

Percent embeddedness of each matrix particle measured was calculated using the following formula:

$$E = d2 / d1$$

Where: E = % Embedded

d1 = The longest diameter of a matrix particle (between 4.5 and 30.0 cm) perpendicular to the plane of embeddedness.

d2 = The distance along (d1) covered by fine sediment (<6.3 mm diameter) or "embedded" in the stream bottom.

The hoop was repeatedly thrown until a total of 100 matrix particle measurements were made at each morphological position. After taking 100 measurements, all remaining matrix particles in the last hoop were measured to avoid any bias against selecting the upper or larger particles. All particles wholly or partially within the hoop were measured. Measurement of particles continue to a depth where particles are no longer in contact with the water

column, i.e. where interstitial spaces permit free flowing water to contact the particles. This procedure normally results in all particles at least partially free of contact with fines being measured for embeddedness.

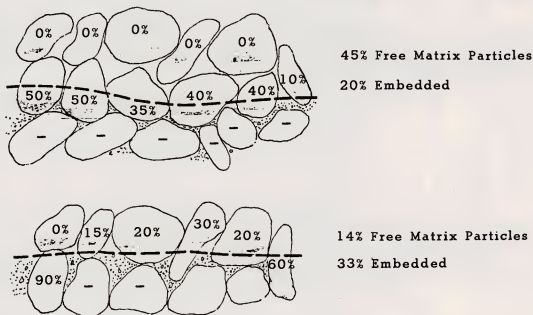


Figure 4. Diagram of two hypothetical stream substrate crosssections with tow different levels of embeddedness.

A linear profile of each sample site along the thalweg was established using permanent elevation reference points. A channel crosssection was established at each site. Boundaries of each station were marked with flagging and a photo record of each station and its boundaries was recorded. Permanent reference points with distances and bearings to stations boundaries were recorded. Site locations were identified on aerial photos and on 2.64"/mile quads. Site and station documentation is kept in individual file folders in the office of the Zone Fisheries Biologist.

#### MACROINVERTEBRATE PROCEDURES, ANALYSIS AND DOCUMENTATION

##### METHODS

Macroinvertebrates were collected at the riffle stations for each site identified for embeddedness analysis. Five samples of 1 square foot were collected from within the site boundaries using a modified Surber Sampler. Samples were collected during a 2-week period in the fall to provide

consistency of samples for future comparison. Individual samples are labeled and preserved in 70 percent alcohol. During 1985 47 samples were collected from 11 stations on 8 streams(Mangum, 1986).

Analysis was completed by Dr. Fred Mangum, Forest Service Aquatic Lab, Provo, Utah. He provided qualitative and quantitative analysis, including confidence limits with standard deviation, standard error, and coefficient of variation for replications. He has also assisted in an analysis of the relative embeddedness with community structure and biomass of invertebrates.

For the six streams with embeddedness evaluations, a specialized analysis procedure was used to quantify invertebrate occurrence by their ecological niche(Figure 5) to evaluate the change in invertebrate structure with change in sediment levels.

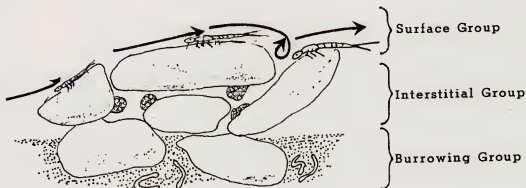


Figure 5. Diagram of hypothetical stream crosssection indicating the distribution of a variety of insect groups within or on the substrate.

## FISH POPULATION PROCEDURES, ANALYSIS AND DOCUMENTATION

### PROCEDURE

Fish population estimates were completed in the immediate vicinity of embeddedness sampling station that the Forest Service has located. Additional sampling sites may be added on study drainages to evaluate spatial distribution changes, fish movement patterns, and habitat selection by indigenous fish species. The sampling schedule began with fish population estimates in August and September, 1985 and will be repeated in March or April, 1986. November or December population surveys may be attempted on selected streams if time permits.

One of three proven fish population estimating techniques will be used. Two of the methods use Chapman's modification of the Peterson formula described by Ricker, 1975. Variance of the estimates will be estimated using Chapman's formula also described in Ricker, 1975. Both of these estimators of population abundance involves marking and recapturing "runs", one method uses electrofishing gear and the other method uses hook and line for marking runs, and snorkel and mask for recapture runs. The third method utilizes electrofishing gear for two-sample population estimates described by Seber, 1973.

Due to the statistical consideration of acquiring an adequate sample size of fish for good population estimates, population study sections require greater length than the embeddedness stations.

Sample stations were permanently marked with steel fence posts on the lower boundary of the section and use local witness geology and/or topography to cross reference the lower boundary. Section length was included as part of the section description.

## RESULTS

### Middle Fork Rock Creek

#### Site Description

Middle Fork is a tributary to Rock Creek managed by the Phillipsburg Ranger District. The study site(Figure 6) has a drainage area of 98 square miles. The study site is located in T4N, R15W, SE1/4, SE1/4, SE1/4 of Section 18. The drainage is dominated by Belt series derived soils. The site is located in a type C channel with an overall surface gradient during summer flows of 0.79%. A riffle, run and pool tailout were selected for study. Active channel width was 47 feet at the study site.

#### Embeddedness Results

Table 1 displays the 1985 embeddedness results. Mean embeddedness ranged from .30 in the run to .41 in the pool tailout. Free matrix percentages expressed this variability in greater magnitude, ranging from .16 to .47 respectively. Mean particle diameter perpendicular to the plane of embeddedness measured for embeddedness(those particles between 4.5 and 30.0 cm) riffle, run and pool tailout were 7.6 cm, 8.2 cm, and 7.4 cm respectively. Figures 7-9 display the histograms for the particles measured at each station.

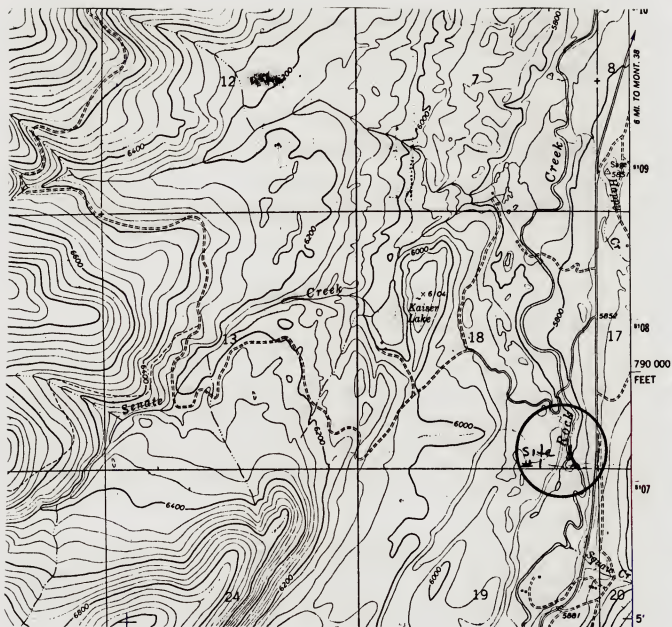


Figure 6. Site location map of Middle Fork Rock Creek

Table 1. Embeddedness and free matrix values for 1985 samples for a riffle, run and pool tailout in the Middle Fork of Rock Creek.

STREAM	SITE	STA.	TYPE	% GRAD.	N	% FREE	MEAN	STD.DV.	VARIANCE
MID.FK.ROCK CR.	1	A	RUN	-1.09	112	16.1	.414	.261	.068
MID.FK.ROCK CR.	1	B	POOL T.	+8.90	107	46.7	.296	.317	.100
MID.FK.ROCK CR.	1	C	RIFFLE	-1.12	101	25.7	.370	.276	.076

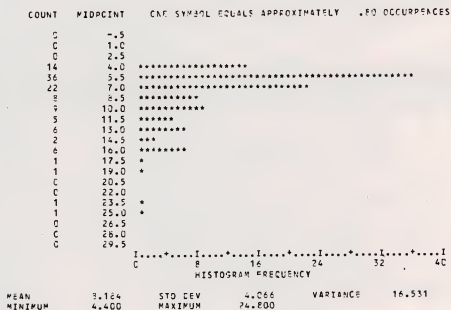
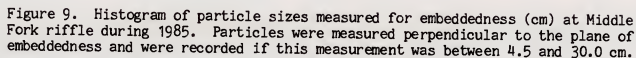


Figure 7. Histogram of particle sizes measured for embeddedness (cm) at Middle Fork run during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



Figure 8. Histogram of particle sizes measured for embeddedness (cm) at Middle Fork pool tailout during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



A total of 36 taxa were represented in the samples analyzed. Those taxa requiring interstitial spaces made up 31% of the total taxa, 11% of the numbers, and 26% of the biomass. Sediment tolerant species made up 28% of the taxa, 46% of the numbers and 27% of the biomass. Taxa that were moderately tolerant to sediment had the highest biomass. Standing crop of invertebrates was 4.3 gm/m<sup>3</sup>. The BCI value of 98 indicates that this stream is close to its potential (Mangum, 1986).

There were no population estimates developed for this site during 1985.

West Fork of Rock Creek is located on the Phillipsburg Ranger District. Five sites were chosen for evaluation on the West Fork of Rock Creek. Site one (Figure 10) has a drainage area of 39.8 square miles with 73 miles of road, or 1.8 miles of road per section. With the exception of 1.6 miles, all of these roads were constructed prior to 1970, with most being constructed in the period 1960-1970. The study site is located in T5N, R17W, NW1/4, SW1/4, S1/4 of Section 2

at elevation 6390. It drains Idaho batholith, Missoula group and glacial till soils. Site 1 is located in a type C channel with an surface gradient during low flows of 0.28%. A riffle, run, and pool tailout were selected for evaluation. Active channel width was 38 feet at the site 1.

Site 2(Figure 11) drains 86.3 square miles with 121 miles of road, or 1.40 miles of road per section. With the exception of approximately 6 miles of road constructed in 1978 and 1984, the roads were constructed prior to 1970. The study site is located in T6N, R16, SE1/4, SW1/4, NE1/4 Section 35 at elevation 5380. The site is located in a type C channel with an overall surface gradient during summer flows of 1.15%. Appendix provides a gradient profile of the site with the boundaries of the morphological positions sampled indicated. A riffle, run, and pool tailout were selected for evaluation. Active channel width was 130 feet at the study site.

Sites 3, 4, 5 (Figures 12-14) were established to measure pool displacement by increased sediment because all sites were composed of entirely gneissic granitic substrate and normal embeddedness measurement techniques were not feasible. At each of these sites at least 10 permanent transects were established across a single pool using a level and rod. Site 3 is located a approximately .5 miles downstream from the mouth of Bowles Creek at T5N, R17W, SW1/4, SW1/4, SW1/4 Section 9 at elevation 6495. Site 4 is located .2 miles upstream from the mouth of Bowles Creek at T5N, R17W, NE1/4, SW1/4, NE1/4 of Section 17 at elevation 6505. Site 5 is located approximately .5 miles upstream from the mouth of Bowles Creek at T5N, R17W, NW1/4, NW1/4, SE1/4 Section 17 at elevation 6510.

#### Embeddedness Results

Table 2 displays the embeddedness and free matrix particle values for the 1985 sampling period.

For Site 1 mean particle diameter perpendicular to the plane of embeddedness measured for embeddedness(those particles between 4.5 and 30.0 cm) riffle, run and pool tailout were 7.4 cm, 6.8 cm, and 6.4 cm respectively. For Site 2, means were 8.4 cm, 8.4 cm, and 8.1 cm respectively. Figures 15-20 display the histograms for the particles measured at each station.

Table 2. Embeddedness and free matrix values for 1985 samples for a riffle, run and pool tailout in the West Fork of Rock Creek.

STREAM	SITE	STA.	TYPE	% GRAD.	N	% FREE	MEAN	STD.DV.	VARIANCE
WEST FK.ROCK CR.	1	A	POOL T.	+11.90	102	21.6	.368	.249	.062
WEST FK.ROCK CR.	1	B	RUN	+ 0.50	106	2.8	.475	.192	.037
WEST FK.ROCK CR.	1	C	RIFFLE	- 2.03	121	19.8	.455	.284	.080
WEST FK.ROCK CR.	2	A	RUN	- 0.93	104	22.1	.416	.301	.090
WEST FK.ROCK CR.	2	B	POOL T.	+15.90	107	47.7	.242	.264	.070
WEST FK.ROCK CR.	2	C	RIFFLE	- 1.25	101	33.7	.327	.287	.082

Contour maps of the pool sampled at sites 3,4, and 5 are displayed in Figures 21-23.



Figure 10. Site location map of West Fork Rock Creek Site 1.

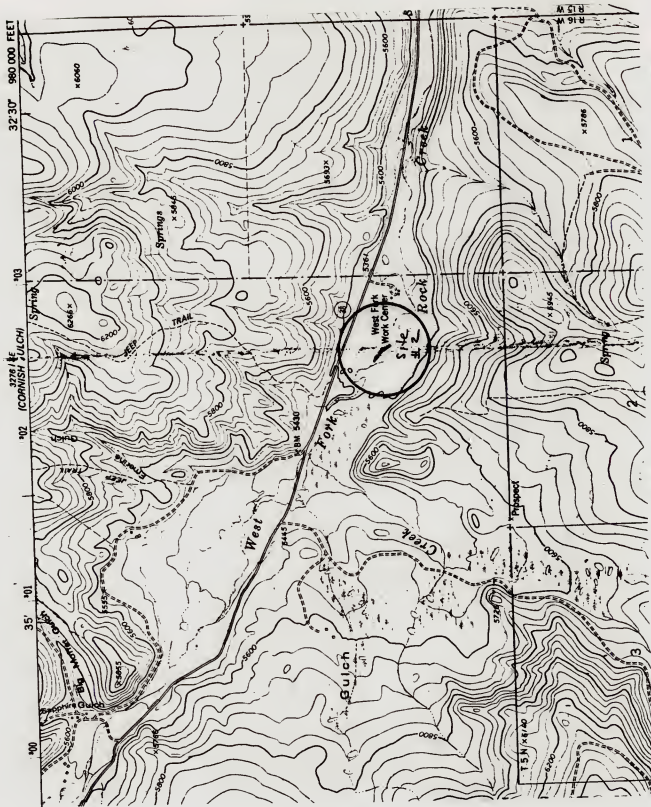




Figure 12. Site location map of West Fork Rock Creek Site 3.

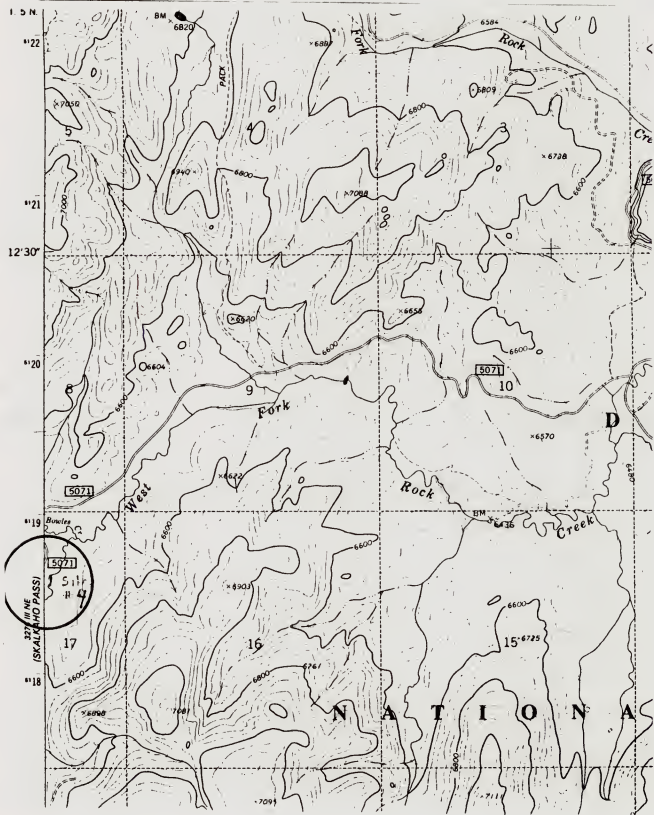


Figure 13. Site location map of West Fork Rock Creek Site 4.

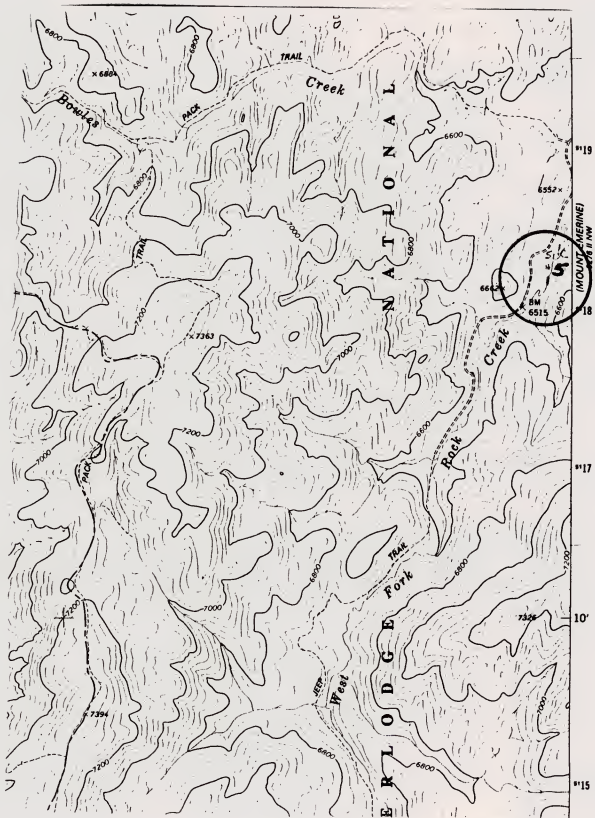


Figure 14. Site location map of West Fork Rock Creek Site 5.

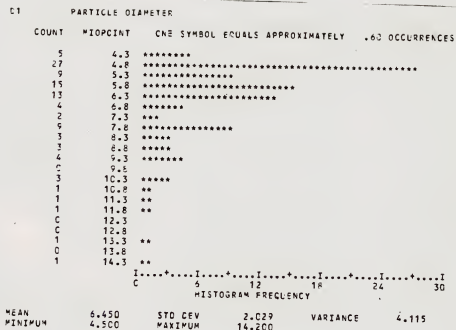


Figure 15. Histogram of particle sizes measured for embeddedness (cm) at West Fork Site 1 pool tailout during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.

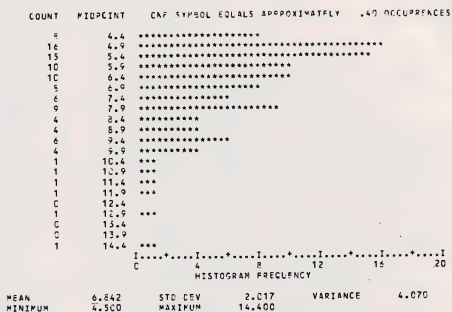


Figure 16. Histogram of particle sizes measured for embeddedness (cm) at West Fork Site 1 run during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



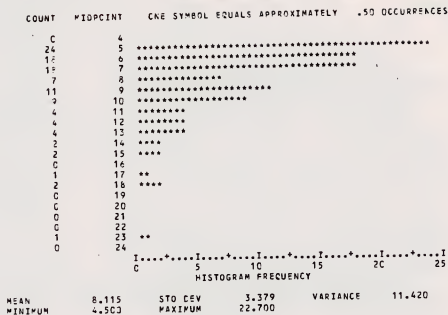


Figure 19. Histogram of particle sizes measured for embeddedness (cm) at West Fork Site 2 pool tailout during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



Table 3. Fish population estimates for a 300 meter length of West Fork Rock Creek at two sites during 1985.

STREAM	LOCATION	SIZE CLASS	ALL TROUT	WS CUTTHROAT	OTHER TROUT	WHITEFISH
W.FK ROCK	SITE 1	TOT. POP.	121	93	28	30
~	~	4"-5.9"	54	43	11	~
~	~	6"+	67	50	17	30
W. FK ROCK	SITE 2	TOT. POP.	70	61	9	~
~	~	4"-5.9"	40	31	9	~
~	~	6"+	30	30	~	~



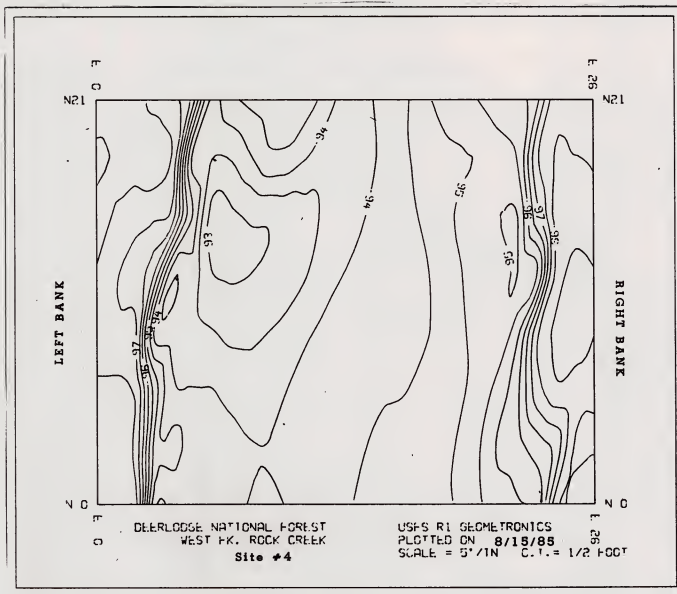


Figure 22. 1985 contour diagram of pool transect at West Fork Site 4.

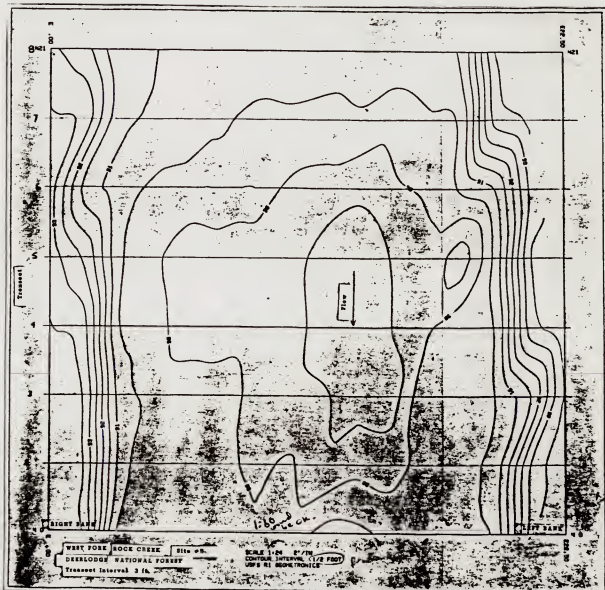


Figure 23. 1985 contour diagram of pool transect at West Fork Site 5.

## Sand Basin Creek

### Site Description

Sand Basin Creek is a tributary to the West Fork of Rock Creek managed by the Phillipsburg Ranger District. Study site 1 (Figure 24) has a drainage area of 11.1 square miles with 12.8 miles of road and an existing road density of 1.2 miles per section. All of these roads were constructed from 1960-1965. Study site 1 is located in T5N, R17W, NE1/4, SW1/4, SW1/4 of Section 11. The study area drains primarily Idaho Batholith derived soils, but also contains some Missoula group and glacial tills. Site 1 is located in a type C channel with an overall surface gradient during summer flows of 0.89%. Two riffles, two runs, and a pool tailout were selected for study.

Study site 2 (Figure 25) is located in T5N, R17W, SW1/4, SW1/4, SW1/4 of Section 9. Site 2 is located in a type C channel. Two pools were selected for study. Active channel width was 11-26(mean=18.5) feet at the study site.

### Embeddedness Results

Tables 4-5 details the embeddedness and free matrix particles for 1985 sampling on Sand Basin Creek Site 1. Due to the total grossic sand makeup of the substrate at Site 2, embeddedness monitoring was not feasible. Instead, pool contour profiles were developed for two pools. The results of this effort are presented in Figure 31. Site 1, although only 3 miles downstream from the total sand substrate found in Site 2 also had the lowest embeddedness in the pool tailout (Station B) found at any site and station in Rock Creek, as well as Bitterroot or Lolo sampling.

For Site 1 mean particle diameter perpendicular to the plane of embeddedness measured for embeddedness(those particles between 4.5 and 30.0 cm) two riffles, two runs and pool tailout were as follows: Station 2 pool tailout, 6.2 cm; Station 3 riffle, 7.4 cm; Station 4 run, 7.3 cm; Station 5 riffle, 7.6 cm; Station 6 run, 7.7 cm. Figures 26-30 display the histograms for the particles measured at each station. Mean particle size measured was not determined for Station 2 because the substrate not measured for embeddedness and consisted of only grossic material.

Table 4 . Embeddedness and free matrix values for 1985 samples for two riffles, two runs and a pool tailout in Sand Basin Creek.

STREAM	SITE	STA.	TYPE	% GRAD.	N	% FREE	MEAN	STD.DV.	VARIANCE
SAND BASIN CR.	1	B	POOL T.	+16.64	101	75.2	.092	.193	.037
SAND BASIN CR.	1	C	RIFFLE	-2.48	105	22.5	.389	.253	.064
SAND BASIN CR.	1	D	RUN	+0.83	114	26.3	.370	.254	.065
SAND BASIN CR.	1	E	RIFFLE	-1.36	104	4.8	.468	.199	.040
SAND BASIN CR.	1	F	RUN	+1.09	106	7.5	.506	.231	.053

Table 5. T-test results of embeddedness levels found between the same morphological positions sampled in Sand Basin Creek at Site 1 during 1985.

Compared Stations	Results	Two tailed probability
Sand Basin Riffles	Significant difference at .05 level	.014
Sand Basin Runs	Significant difference at .01 level	.000



Figure 24. Site location map of Sand Basin Creek Site 1.

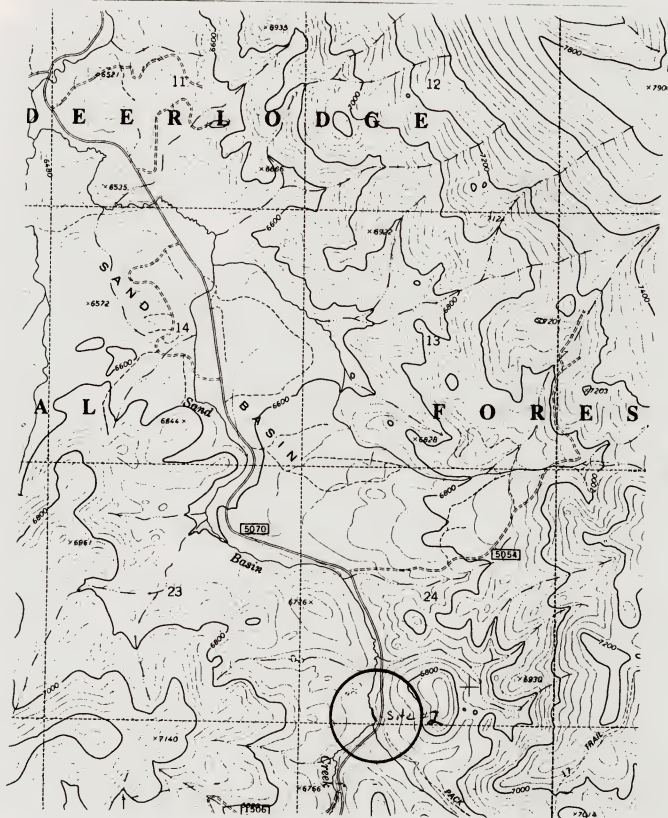


Figure 25. Site location map of Sand Basin Creek Site 2.

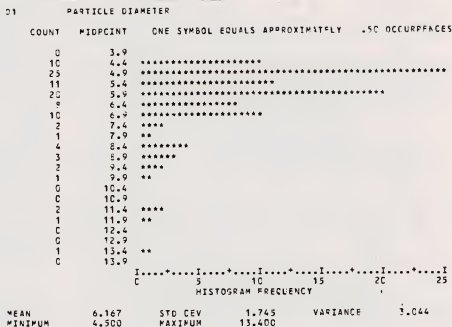


Figure 26. Histogram of particle sizes measured for embeddedness (cm) at Sand Basin Creek Site 1 Station B pool tailout during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.

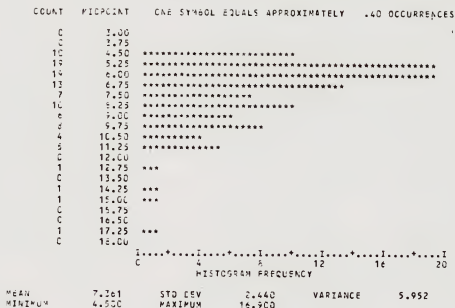


Figure 27. Histogram of particle sizes measured for embeddedness (cm) at Sand Basin Creek Station C riffle during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



Figure 28. Histogram of particle sizes measured for embeddedness (cm) at Sand Basin Creek Station D run during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.

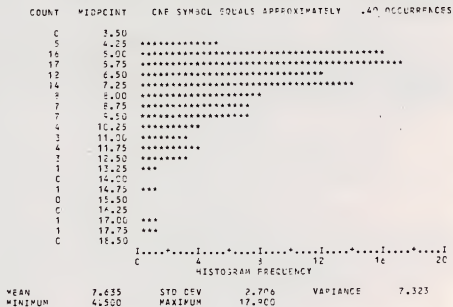
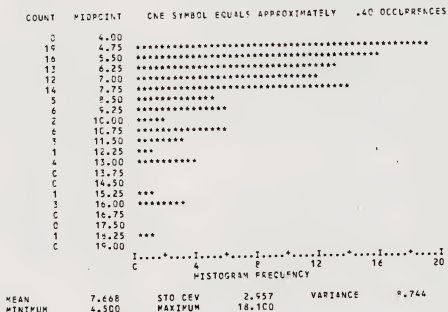


Figure 29. Histogram of particle sizes measured for embeddedness (cm) at Sand Basin Site 1 Station E riffle during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



At site two in lieu of embeddedness, a contour map was developed for two pools to establish a baseline for comparison over time. The intent of this effort is to measure whether pool space, an important fish habitat parameter is reduced by additional sedimentation as development occurs. Figures 31-32 display the contour maps that were developed in 1985.

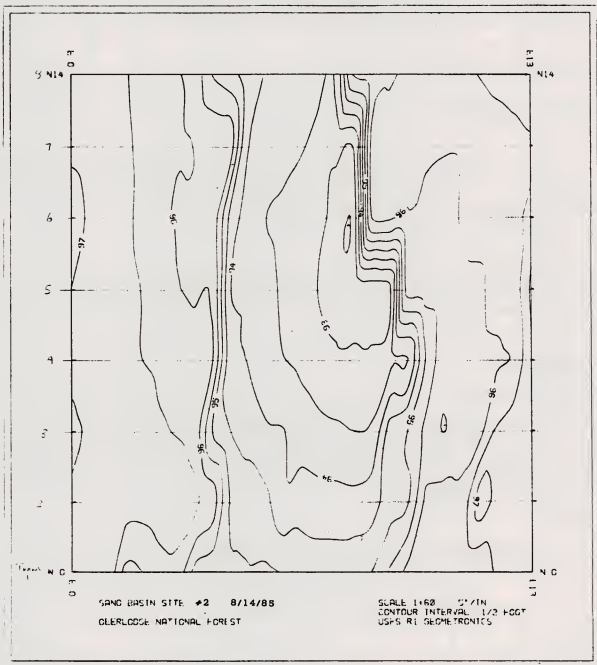


Figure 32. 1985 contour diagram of pool transect at Sand Basin Site 2.  
Invertebrate Results

Samples were collected at both stations C and W, with results of analysis indicating similar community structure. At station C, 36% of the taxa required interstitial spaces and represented 11% of the numbers and 23% of the biomass. Sediment dwelling taxa made up 33% of the taxa, 61% of the numbers, and 50% of the biomass. At Station E, 28% of the taxa required interstitial spaces, representing 6% of the numbers and 26% of the biomass. Standing crop at Station C and E was 4.2 and 8.6 gm/m<sup>3</sup> respectively (Mangum, 1986).

#### Fish Population results

Table 6. Fish population estimates for a 300 meter length of Sand Basin Creek at two sites during 1985.

STREAM	LOCATION	SIZE CLASS	ALL TROUT	WS CUTTHROAT	OTHER TROUT	WHITEFISH
SAND BASIN	SITE 6	TOT. POP.	81	73	8	5
~	~	4"-5.9"	49	41	8	~
~	~	6"+	32	32	~	5
SAND BASIN	SITE ~	TOT. POP.	88	88	~	~
~	~	4"-5.9"	54	54	~	~
~	~	6"+	34	34	~	~

#### Bowles Creek

##### Site Description

Bowles Creek is a tributary to the West Fork of Rock Creek managed by the Phillipsburg Ranger District. A bottom contour transect was established on a pool of Bowles Creek located approximately .4 miles upstream from its confluence with the West Fork of Rock Creek at T5N, R17W, SW1/4, SW1/4, SE1/4 Section 8 at elevation 6510 (Figure 33).

##### Results

A contour diagram of the pool transect is displayed in Figure 34.

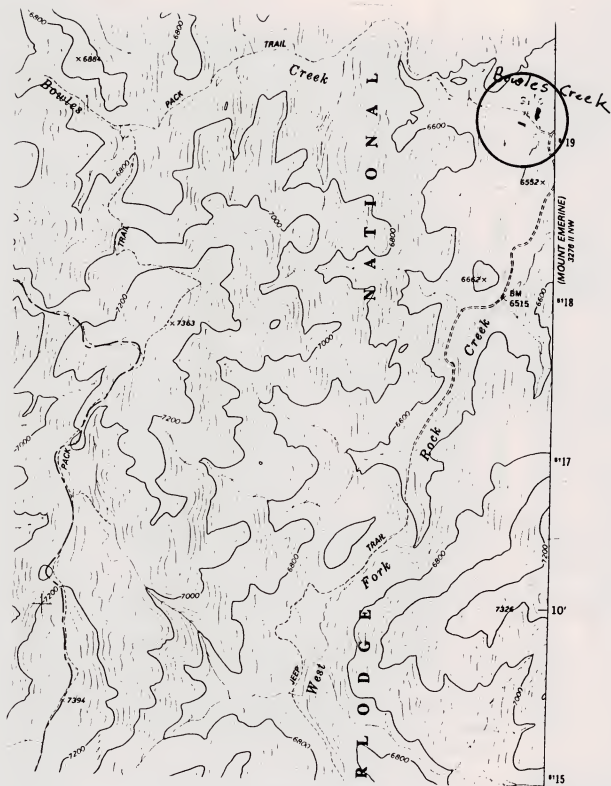


Figure 33. Site location map of Bowles Creek Site 1.

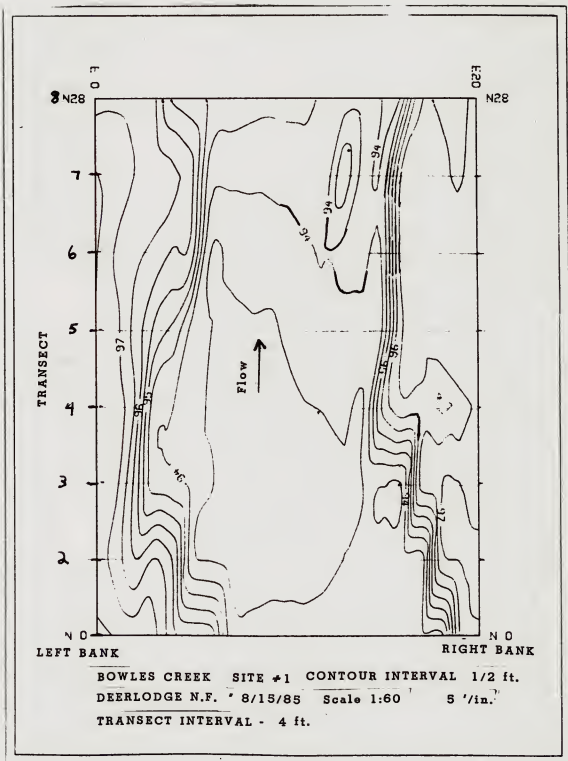


Figure 34. Contour diagram of pool transect on Bowles Creek Site 1.

## Ross Fork of Rock Creek

### Site Description

Ross Fork Rock Creek is a tributary to main Rock Creek managed by the Phillipsburg Ranger District. Study site 1 (Figure 35) has a drainage area of 71.6 square miles with 24 miles of road and an existing road density of 0.34 miles per section. With the exception of approximately 3 miles constructed in 1982, all roads in the drainage were constructed prior to 1966. Study site 1 is located in T5N, R16W, N1/2, SW1/4, NE1/4 of Section 26. The study area drains primarily Idaho Batholith derived soils, but also contains some Belt series and glacial tills. Site 1 is located in a type C channel. A riffle, run, and a pool tailout were selected for study. Active channel width was 41 feet at the study site.

### Embeddedness Results

Embeddedness results are displayed in Table 7. Mean particle diameter perpendicular to the plane of embeddedness measured for embeddedness(those particles between 4.5 and 30.0 cm) riffle, run and pool tailout were 8.6 cm, 9.1 cm, and 8.1 cm respectively. Figures 36-38 display the histograms for the particles measured at each station.

Table 7. Embeddedness and free matrix values for 1985 samples for a riffle, run and pool tailout in the Ross Fork of Rock Creek.

STREAM	SITE	STA.	TYPE	% GRAD.	N	% FREE	MEAN	STD.DV.	VARIANCE
ROSS FK. ROCK CR.	1	A	RIFFLE	-0.20	103	5.8	.549	.209	.044
ROSS FK. ROCK CR.	1	B	RUN	-0.86	108	5.6	.563	.215	.046
ROSS FK. ROCK CR.	1	C	POOL T.	~	106	35.8	.340	.289	.084



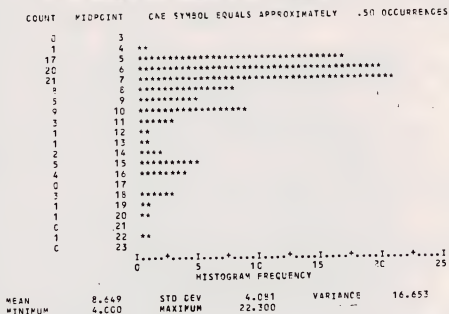


Figure 36. Histogram of particle sizes measured for embeddedness (cm) at Ross Fork rifle during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.

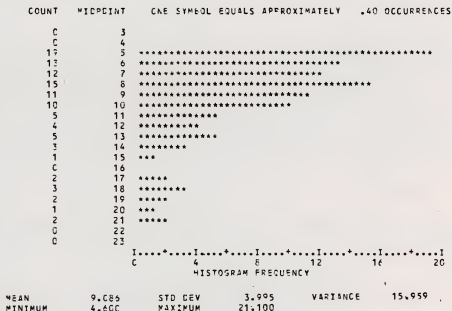


Figure 37. Histogram of particle sizes measured for embeddedness (cm) at Ross Fork run during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



Figure 38. Histogram of particle sizes measured for embeddedness (cm) at Ross Fork pool tailout during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.

#### Invertebrate Results

Invertebrate analysis indicates the community reflects at least moderate amounts of sediment and organic enrichment. Clean water species were present, but not in resident numbers. Sediment tolerant taxa, particularly Oligochaetes, were fairly abundant, which are most numerous where sedimentation and organic enrichment is present. Species requiring interstitial spaces made up just 5% of the community numbers, but made up 42% of the biomass. Sediment dwelling taxa made up 31% of the taxa, 69% of the individuals, and 33% of the biomass (Mangum, 1986).

#### Fish Population results

Table 8. Fish population estimates for a 300 meter length of the Ross Fork Rock Creek during 1985.

STREAM	LOCATION	SIZE CLASS	ALL TROUT	WS CUTTHROAT	OTHER TROUT	WHITEFISH
ROSS FORK	SITE 1	TOT. POP.	131	127	4	-
-	-	4"-5.9"	66	66	-	-
-	-	6"+	65	61	4	-

#### Main Stem of Rock Creek

#### Site Description

Main Rock Creek is a tributary to the Clark Fork and is managed by the Phillipsburg Ranger District. Study site 1 (Figure 39) has a drainage area of 457 square miles. The study site is located in T6N, R15W, SW1/4, SW1/4, SE1/4 SW1/4 of Section 5. The study area drains a mixture of Idaho Batholith, Missoula, Belt Series, and glacial tills. The site is located in a type C channel with an overall surface gradient during summer flows of 0.61%. A riffle and a pool tailout were selected for study. Active channel width was 75 feet at the study site.

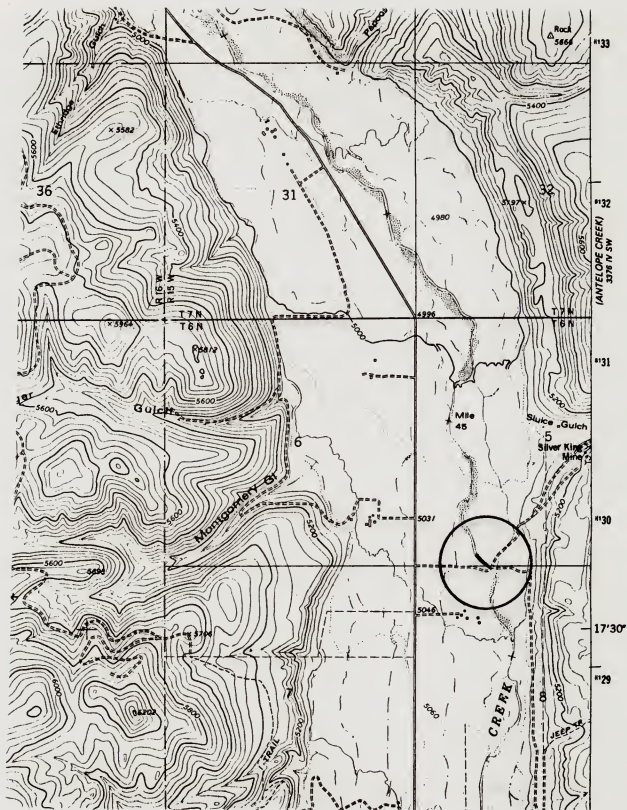


Figure 39. Site location of Site 1 on main stem of Rock Creek.

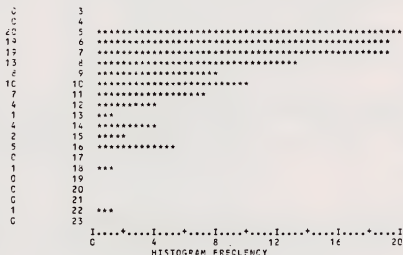
# Embeddedness Results

Embeddedness measured at the sites during 1985 are displayed in Table 9. Mean particle diameter perpendicular to the plane of embeddedness measured for embeddedness(those particles between 4.5 and 30.0 cm) riffle and pool tailout were 8.4 cm and 7.6 cm respectively. Figures 40-41 display the histograms for the particles measured at each station.

Table 9. Embeddedness and free matrix values for 1985 samples for a riffle, and pool tailout in the Main stem of Rock Creek.

STREAM	SITE	STA.	TYPE	% GRAD.	N	% FREE	MEAN	STD.DV.	VARIANCE
ROCK CR. (MAIN)	1	A	RIFFLE	-0.72	114	33.3	.355	.292	.085
ROCK CR. (MAIN)	1	B	POOL T.	+1.33	105	60.0	.212	.286	.082

COUNT MIDPOINT ONE SYMBOL EQUALS APPROXIMATELY .40 OCCURRENCES



MEAN 8.380 STD DEV 3.438 VARIANCE 11.822  
MINIMUM 4.500 MAXIMUM 22.500

Figure 40. Histogram of particle sizes measured for embeddedness (cm) at Main Stem Rock Creek riffle during 1985. Particles were measured perpendicular to the plane of embeddedness and were recorded if this measurement was between 4.5 and 30.0 cm.



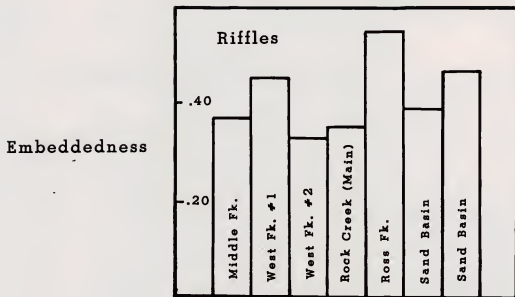


Figure 42. Riffle embeddedness for 7 stations on 5 Deerlodge National Forest streams sampled in 1985.

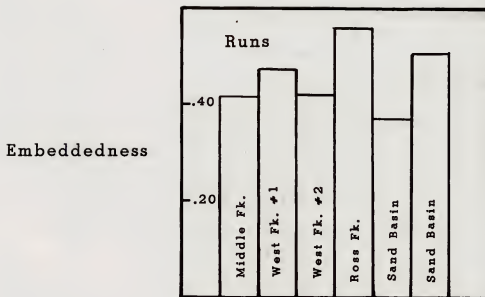


Figure 43. Run embeddedness for 6 stations on 4 Deerlodge National Forest streams sampled during 1985.

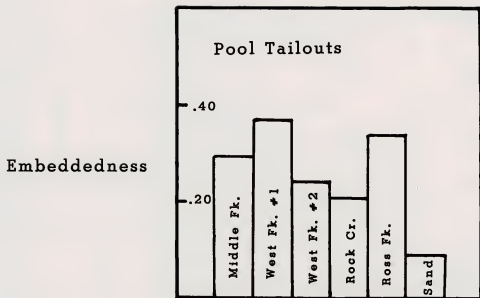


Figure 44. Pool tailout embeddedness for 6 stations on 5 Deerlodge National Forest streams sampled during 1985.

A simple regression was developed to evaluate the strength of the relationship between embeddedness values and the percentage of free matrix particles in the sample. A  $r^2$  value of .92 (Figure 45) was evidence that an excellent relationship exists between the two values on the Deerlodge and when the total 1985 data gathered from the Deerlodge, Bitterroot and Lolo, and good relationship ( $r^2 = .81$ ) remains (Figure 46).

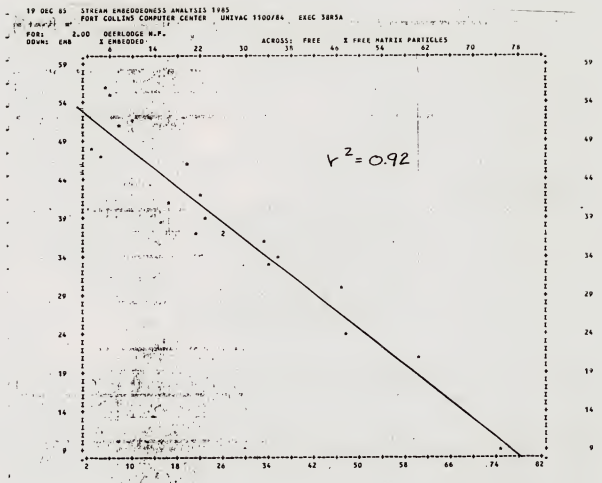


Figure 45. Relationship between embeddedness and free matrix particles found on the Deerlodge National Forest in 1985.

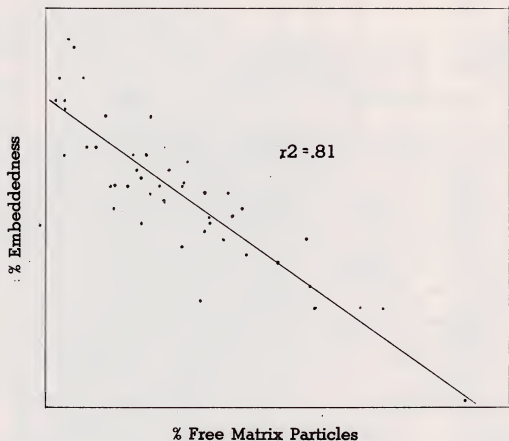


Figure 46. Relationship between embeddedness and free matrix particles found on the Deerlodge, Bitterroot and Lolo National Forests in 1985.

#### Macroinvertebrate Community Structure Related to Embeddedness or Free Matrix

Using a multiforest combination of 20 invertebrate sampling stations, of which 6 stations were on the Deerlodge, a series of linear regressions were developed to test the relationship of embeddedness and free matrix particle frequency with the composition of the invertebrate community. Relationships were developed for invertebrate groups requiring like habitat, i.e. taxa requiring interstitial spaces, taxa utilizing top of substrate, and a sediment tolerant group. Separate relationships were developed for numbers of taxa in each group, community numbers in each group, and biomass in each group. Table 10 displays the  $r^2$  values for each relationship.

Table 10.  $r^2$  values for linear relationship between embeddedness, free matrix particles and invertebrate community structure for 20 sample stations on the Deerlodge, Lolo, and Bitterroot National Forest.

<u>Particle Measurement</u>	<u>Invertebrate Measurement</u>	<u><math>r^2</math> value</u>
Embeddedness %	% Taxa are Sediment Tolerant	.05
Embeddedness %	% Community Numbers are Sed. Tolerant	.21
Embeddedness %	% Biomass is Sediment Tolerant	.04
Embeddedness %	% Taxa require Interstitial Spaces	.00
Embeddedness %	% Comm. Numbers require Interstic. Space	.07
Embeddedness %	% Biomass require Interstitial Spaces	.08
Embeddedness %	% Taxa use Top of Substrate	.05
Embeddedness %	% Community Numbers use Top of Substrate	.14
Embeddedness %	% Biomass use Top of Substrate	.32
Free Matrix %	% Taxa are Sediment Tolerant	.06
Free Matrix %	% Community Numbers are Sed. Tolerant	.22
Free Matrix %	% Biomass is Sediment Tolerant	.04
Free Matrix %	% Taxa Requiring Interstitial Spaces	.00
Free Matrix %	% Comm. Numbers Req. Interstic. Space	.02
Free Matrix %	% Biomass Requiring Interstitial Space	.07
Free Matrix %	% Taxa Using Top of Substrate	.17
Free Matrix %	% Community Numbers use Top of Substrate	.24
Free Matrix %	% Biomass Using Top of Substrate	.22

These weak  $r^2$  values do not support the linear relationship between invertebrate community structure as defined and the quantification of embeddedness and the availability of free matrix particles. Possible explanations are presented in the Discussion section of this report.

#### Fish Population Versus Existing Embeddedness

Simple regressions were developed for embeddedness and fish population data. Fifty three regressions were developed to analyze species and size groups of fish against run, riffle, or pool tailout embeddedness on combined Deerlodge and Bitterroot data. R-squared values were usually extremely low indicating no significant relationship. There was one R-squared value exceeding .7, however the sample size of these test were limited to only three observations and therefore cannot be considered to be a valid test.

#### DISCUSSION

The first year of data indicate that the embeddedness and free matrix particle measurements are feasible indicators of substrate sedimentation on the Deerlodge National Forest. A variety of embeddedness and free matrix particle values ranging from .09 to .56 and 3% to 75% respectively suggest that there is enough variability between sample stations to detect differences. The embeddedness and free matrix particle obtained on the Deerlodge National Forest in 1985 indicate considerable natural variability within streams of different and even the same morphological position. As expected, there is variability between streams.

Embeddedness means for all sampled riffles, runs, and pool tailouts of .42, .46, and .26 respectively may suggest that morphological position in the stream influences stream embeddedness, as does the free matrix particle values of 21%, 14%, and 48% respectively. Greater embeddedness and fewer free matrix particles appeared regularly in runs and riffles sampled compared to the pool tailouts sampled. Bitterroot National Forest data (Munther and Frank, 1986) did not support this relationship. Variability of embeddedness found between stations of the same morphological position on the same stream suggest that each sampling station should be evaluated independently over time for changes in embeddedness values, and should be treated as a separate entity. In the future, we may understand how similar or dissimilar each of these sample stations may change if sediment loading were to change. The similarity of the changes that occur within a stream will be evaluated in future analysis.

Burns(1984) found significant embeddedness differences between groups of heavily developed and undeveloped or partially developed tributaries of the South Fork of the Salmon River in Idaho, a granitic drainage. Mean embeddedness values for partially or undeveloped tributaries was .24 (range .19-.30), while heavily developed drainages had a mean value of .44(range .36-.50). Although Burns did not describe morphological position sampled, the Deerlodge embeddedness values are within the ranges described by Burns for the South Fork tributaries. Burns(1985) found embeddedness values in basalt drainages to range from .12 to .46., suggesting that high embeddedness value can occur in non-granitic streams. This possibility is demonstrated in the Middle Fork of Rock Creek where embeddedness values as high as .41 were observed in this undeveloped, non-granitic drainage. Kelley and Dettman (1980) measured embeddedness values in a reach of Lagunitas Creek, California ranging from .17 to .69 (mean=.42) in glides (runs) and from .10 to .48 (mean=.24) in riffles. They found a strong correlation ( $r^2=.85$ ) between riffle and glide (run) embeddedness and steelhead trout density.

Embeddedness values observed on the Deerlodge should not be compared with embeddedness values cited in literature where surface embeddedness is the measured parameter. We strongly suspect that surface embeddedness values for our sample sites would be substantially lower than our measured embeddedness values on the Deerlodge. We feel our embeddedness measurement more accurately measures true embeddedness than the surface embeddedness evaluation commonly used elsewhere. We propose to evaluate this relationship in 1986 monitoring. There are many Deerlodge examples where free matrix values would suggest that the surface of the substrate was void of fines, however we would record moderate embeddedness. This is because excavation below the surface layer of substrate is commonly necessary to reach the substrate level where all further particles are completely embedded. With our methodology partially embedded material is always encountered and recorded, therefore raising the mean embeddedness value that would be found with surface material only. We expect to be able to develop the correlation between surface embeddedness and excavated embeddedness in next year's sampling.

We did establish a strong correlation ( $r^2=.91$ ) between embeddedness values and percent free matrix particles (Figure 45). This strong correlation suggests that a monitoring method of only sampling free matrix particle occurrence may be able to be converted to embeddedness values with little error. Monitoring only free matrix particle may be appropriate for some situations where there is a need to

approximate that substrate sedimentation is within certain limits. 1985 sampling on the adjacent Lolo National Forest found a good correlation between very fine sediment (.21-.83 mm) and both embeddedness and percentage free matrix particles ( $r^2=.73$  for each) suggesting that either measurement may be used to assess the composition of substrate made up of very fine sediment. These measurements are commonly used to express potential egg survival or fry emergence success.

A high percentage free matrix particle value suggests considerable intergravel interstices available for some aquatic insect species and interstitial use by juvenile and small salmonids. Campbell and Neuner (1985) found interstitial use by rainbow trout up to 150 mm (6 inches) during winter days. Edmundsen, et.al. (1968) found similar behavior and found fish up to 15 cm deep in the substrate. Giger (1973) observed similar behavior for brown trout. We believe that the free matrix value is important in describing the availability of interstitial voids available for both insects and small salmonids that is not available when attempting to interpret methods using substrate composition values such as those obtained by core sampling. We expect there may be a correlation between surface embeddedness values and percentage free matrix values and will investigate this relationship during the 1986 field season.

The low  $r^2$  values for the invertebrate/sediment linear relationships could have several possible explanations. Invertebrate populations could be considerably different in community structure from one drainage to another, as the samples represented differences in geologic type, stream order and site specifically differed in stream gradient. In addition, some sampling error would be expected because it was impossible to sample invertebrates exactly over the same sites as embeddedness, because the exact site was disturbed by excavating for the embeddedness evaluation. However, an effort was made to sample as closely as feasible to reduce this error. We do know, however, that there is some heterogeneity among sample stations, even when the stations have been chosen and delineated for homogeneity. This potential problem should have been minimized, however, by the 5 separate subsamples collected for each station sample. These subsamples were frequently collected from sites intermixed with the embeddedness sample areas. There is the potential that invertebrate taxa assigned to interstitial spaces have other substitute ecological niches or have been wrongly assigned to this ecological niche. We intend to analyze the relationship of individual species occurrence that have very specific habitat niches against embeddedness levels. Suggested species include oligochaetes, chironomids, and Ephemeraella doddsi.

The lack of any relationship between existing embeddedness and existing fish populations examined in 1985 suggest that other environmental factors may be sufficiently different to mask any effect that sediment may have on the population. We intend to quantify the other habitat variables on the fish sample sections in 1986.

#### OTHER DEER LODGE MONITORING

A monitoring effort was initiated in 1985 at two stream crossing sites to attempt to quantify short term changes in habitat conditions downstream from culvert installation activities. One site was the newly installed culvert on Alder Creek as part of the upper Willow Capital Investment road. The other was the scheduled crossing of Meadow Creek by the Happy Creek Capital Investment road.

The method used was to place 3 gallon buckets filled with washed gravel (1-3 inches in diameter) into the substrate so that the top of the bucket was flush with the streambed. Three buckets were placed 40 to 100 feet downstream from the crossing and another group of three buckets were placed immediately upstream from the crossing structure. The intent is to remove the buckets during low flow of 1986 and measure the accumulation of fines in the interstices of the gravel by the use of soil sieves and volumetric displacement methods. This method has been used successfully on the Lolo National Forest where culvert installation has resulted in a range of negligible increase to one site where a 26 times increase in fine sediment was measured (Munther and Frank, 1986).

#### RECOMMENDATIONS FOR MONITORING IN 1986

1. Continue existing stations initiated in 1985 as baseline and to assess annual individual site variability and to evaluate changes that may occur as a result of future land management activities.
2. Add additional embeddedness sites within the same stream reaches presently being monitored to provide greater replications for each morphological position. This appears to be necessary due to the observed variation between sites within the same stream.
4. Develop correlation between embeddedness measurements used by the Deerlodge and surface embeddedness measurements commonly cited in literature by completing a estimate of surface embeddedness at each embeddedness hoop measurement site before excavation begins. This will make interpretations to the literature related to fish consequences more feasible.
5. Develop correlation between surface embeddedness relationships and percentage free matrix particles.
6. Quantify habitat parameters on fish shocking reaches to better explain variability of fish populations between streams. Parameters expected to be measured include pool frequency and quality, cover quantity and type, specific conductance, invertebrate abundance and diversity.
7. Encourage the Deerlodge to continue hydrologic stations on monitored streams to measure both streamflows and bedload movement on a continuous basis, especially during high flow events.

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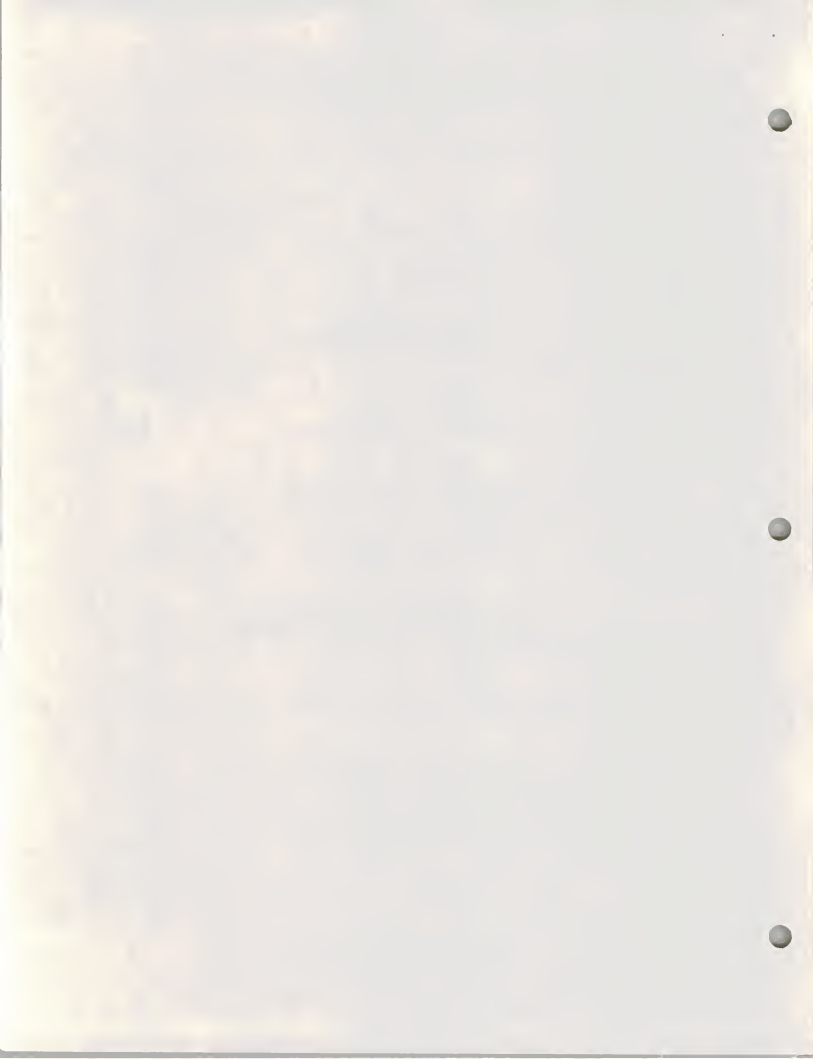
Munther, Greg L. and G. Frank. 1986. 1985 Fisheries Habitat and Aquatic Environment Monitoring Report- Lolo National Forest. Unpublished report for the Lolo National Forest.

APPENDIX



#### EMBEDDEDNESS EVALUATIONS

To determine sediment deposition  
as an indication of fish habitat condition.





**Figure 1.** Sites to be sampled may be riffles, pool tailcuts, or runs such as the above station. Boundaries of each station are documented photographically, using permanent reference points and boundary stakes. A gradient profile is developed for each site.



**Figure 2.** A 2-foot diameter hoop is randomly thrown at each station, several times, and embeddedness of each particle within the hoop is measured. The hoop is rethrown until at least 100 particles are measured.

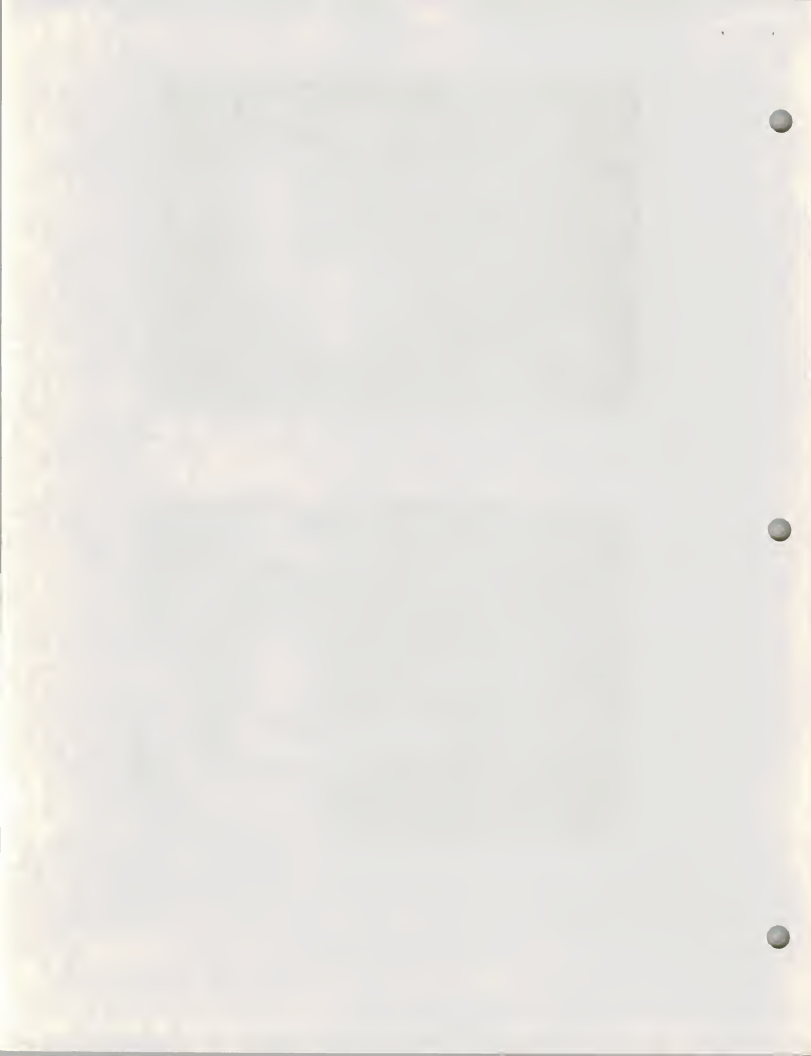




Figure 3. Each particle greater than 2 inches in diameter is extracted from the streambed within the hoop.



Figure 4. Using a special measuring device, each particle is held along the plane of embeddedness, and the total diameter of each particle perpendicular to the plane of embeddedness is measured as well as the length of each particle that is embeddedness recorded.



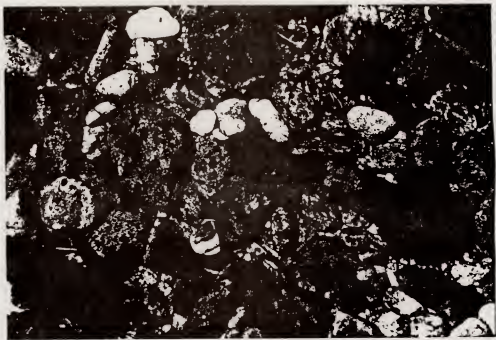
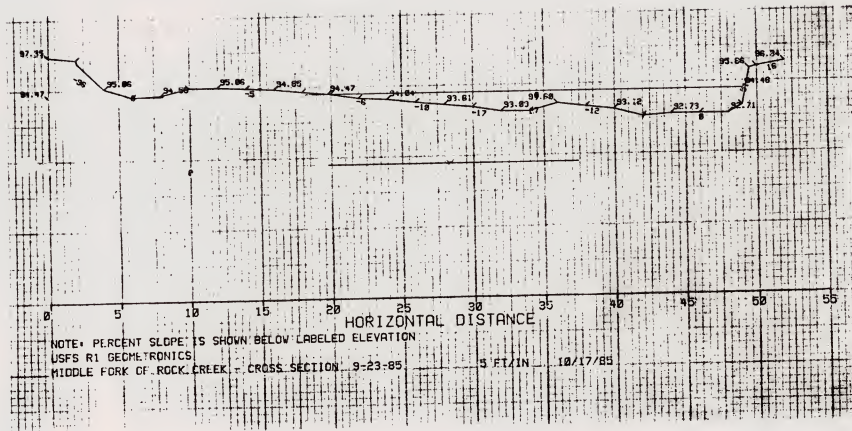


Figure 5. Example of substrate with low embeddedness. Some of these particles are only in contact with other larger substrate and are termed free matrix particles.



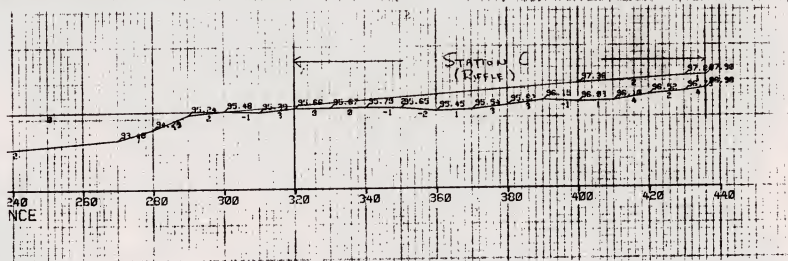
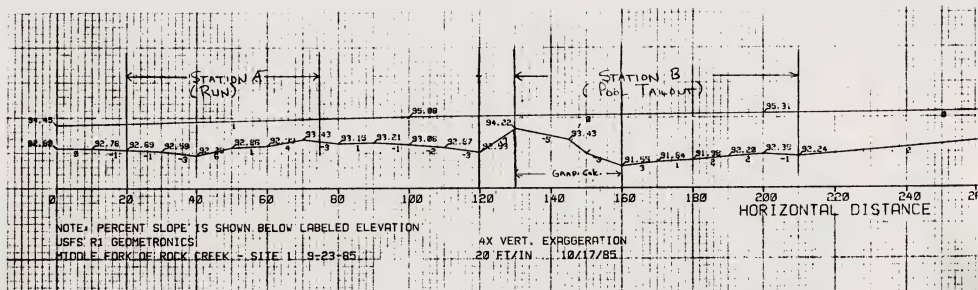
Figure 6. Example of substrate with high embeddedness. Note that a substantial portion of each particle is covered with sediment. There are no free matrix particles present.





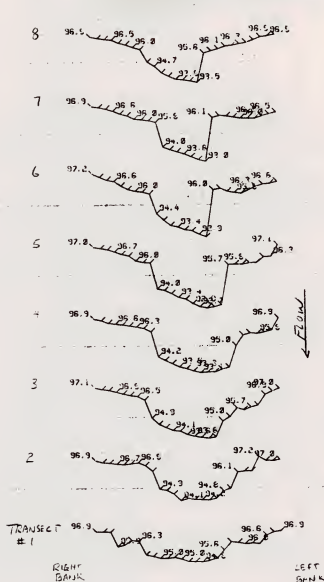
CROSSECTION PROFILE (EXAMPLE)





LINEAR PROFILE (EXAMPLE)





2 5 10 15  
HORIZONTAL DISTANCE

USFS RI GEOMETRONICS  
SAND BASIN SITE #7 8-14-85  
2' INTERVAL BETWEEN TRANSECTS

POOL CONTOUR  
CROSSECTIONS (EXAMPLE)



0 2 4 6 8 10 12 14 16 18 20

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PAGE 18

STATISTICS..

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PLOTTED VALUES -

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4.97397

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R SQUARED -

INTERCEPT (A) -

EXCLUDED VALUES -

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22.27033

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SIGNIFICANCE -

SLOPE (B) -

MISSING VALUES -

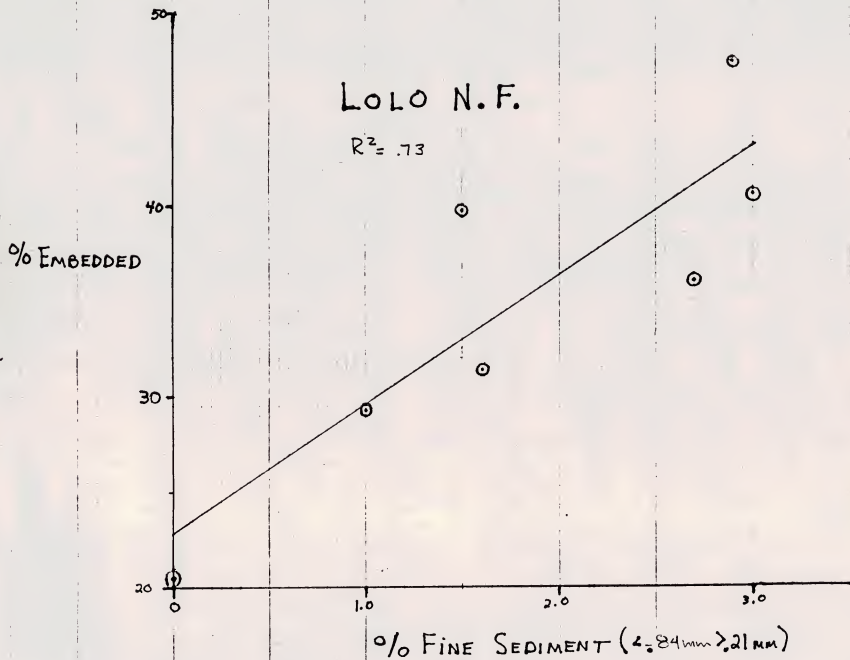
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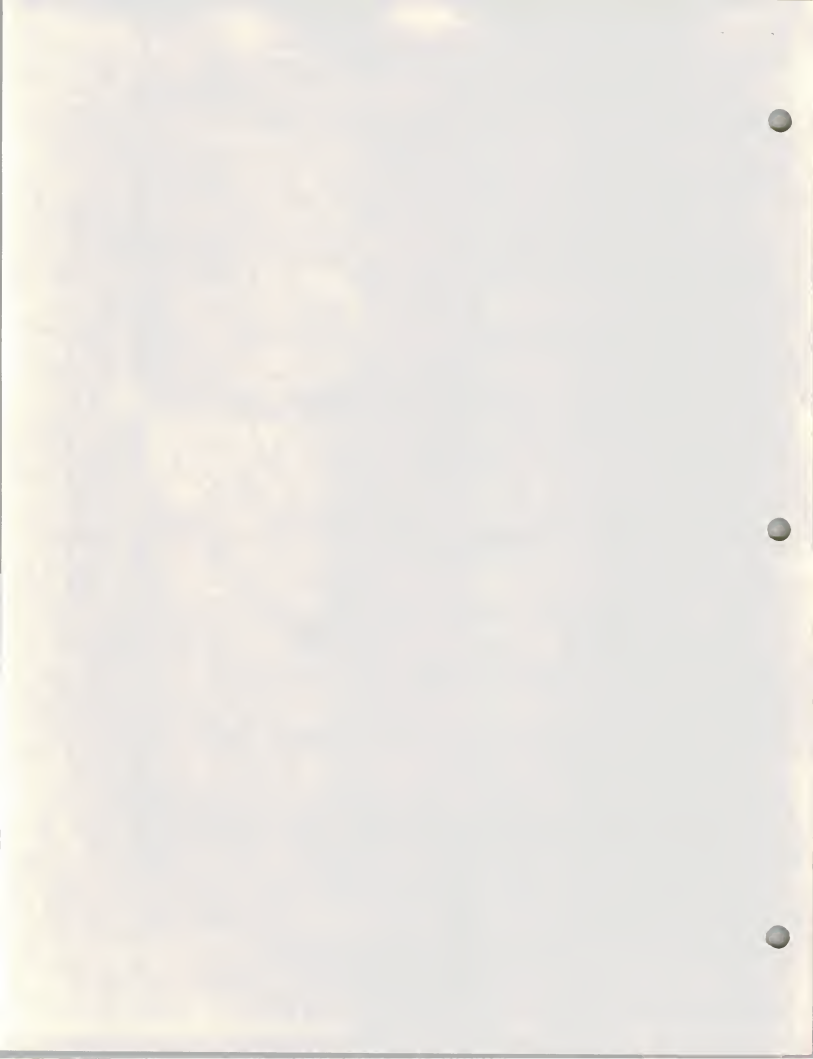
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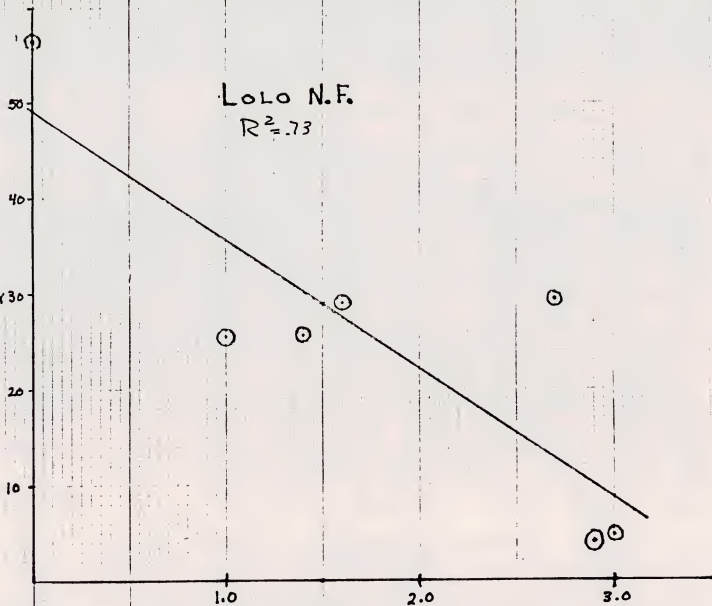




LOLO N.F.

$$R^2 = .73$$

% FREE MATRIX  
PARTICLES



% FINE SEDIMENT (<.84mm - >.21mm)



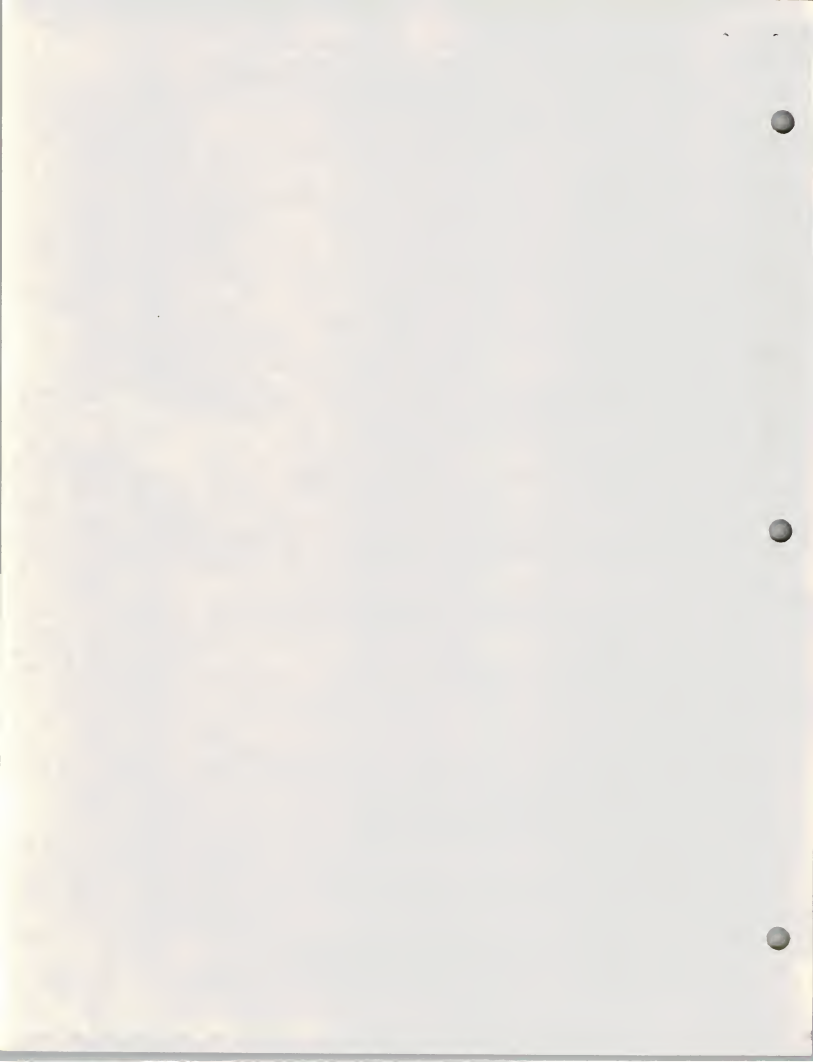
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PAGE 20

STATISTICS..							
CORRELATION (R)-	-.35217	R SQUARED	-	.72620	SIGNIFICANCE	-	.00744
STD ERR OF EST -	10.16930	INTERCEPT (A) -		49.26184	SLOPE (B)	-	-13.45674
PLOTTED VALUES -	7	EXCLUDED VALUES-		0	MISSING VALUES -		0

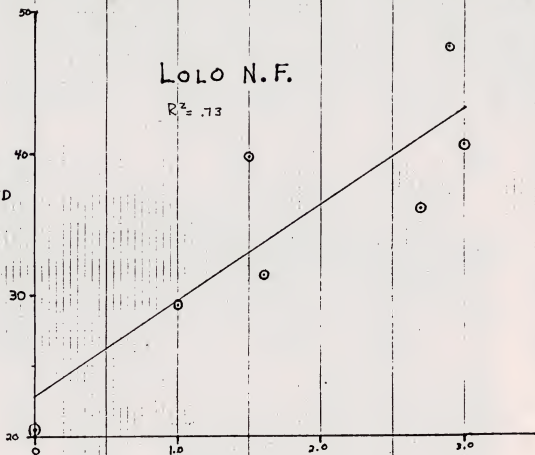
\*\*\*\*\* IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.



LOLO N.F.

$R^2 = .73$

% EMBEDDED



% FINE SEDIMENT (4.75mm > 21um)





